A measuring apparatus includes a freely moving measuring head which is connected to a stationary base unit via light conductors and an electrical cable. The radiation reflected from the sample is simultaneously measured at three different angles. For this purpose, three diode-array spectrometers are provided in the stationary base unit. The spectrum of the radiation illuminating the sample can be simultaneously measured with a fourth diode-array spectrometer.
MEASURING APPARATUS FOR CHARACTERIZING A SURFACE HAVING COLOR DIRECTIONAL REFLECTANCE PROPERTIES

FIELD OF THE INVENTION

The invention relates to a measuring apparatus for characterizing surfaces having color directional reflectance properties. The apparatus includes a light source and several receivers.

BACKGROUND OF THE INVENTION

Surfaces having color directional reflectance properties are present, for example, in metallic paints, iridescent surfaces and in nacreous structures. In such surfaces, not only is the amount of light but also the spectral distribution of the reflected radiation dependent upon direction. From goniophotometric measurements on such surfaces, it is known that measurements of the reflected radiation at three different angles is required to determine a sufficient correspondence between the comparison specimen and the measured specimen.

U.S. Pat. No. 4,479,718 discloses a measuring device for measuring paint containing metallic flakes wherein a light source illuminates the surface at an angle of incidence of 45°. Three detectors are provided for detecting the reflected radiation and these detectors conjointly define respective angles of 15°, 45° and 110° with the radiometer regularly reflected at an angle of 45°.

This known measuring device has the disadvantage that the specimen to be measured have to be brought to the measuring device and must be placed adjacent a measuring opening. This is, for example, not possible in the case of an automobile chassis or structural siding.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a measuring apparatus with which large surfaces having color directional reflectance properties can also be measured.

The measuring apparatus according to the invention is for characterizing a surface having color directional reflectance properties. The measuring apparatus includes: a freely movable measuring head having a head housing; and, a stationary base unit. The stationary base unit includes a base housing; and, a light source mounted in the base housing. First light conductor means conduct light from the light source to the measuring head and light directing means mounted in the measuring head directs the light onto the surface having the directional reflectance properties. A plurality of receiving optics are arranged in the head housing for receiving the light reflected from the surface and second light conducting means conduct the reflected light to the base unit. The base unit further includes a plurality of diode-array spectrometers for receiving the reflected light from corresponding ones of said receiving optics.

An advantageous embodiment of the invention includes a beam splitter plate mounted in the measuring head so as to be disposed in the illuminating beam path of the beam illuminating the surface having color directional reflectance properties. The radiation reflected by the beam splitter plate is conducted through a light conductor to a further diode-array spectrometer in the stationary base unit and is there received as a comparison spectrum.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described with reference to the drawings wherein:

FIG. 1 is a schematic showing the configuration of the entire measuring apparatus according to the invention;

FIG. 2 is a side elevation view, partially in section, showing details of the measuring head of the apparatus of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

In FIG. 1, reference numeral 11 identifies the freely movable measuring head which is connected with the stationary base unit 12 via light conductors (13, 18a to 18b) and electrical cables 14. The base unit includes a lamp housing 15 in which the light source 15a is mounted. The light source 15a is supplied with the necessary current from the electronic and evaluation unit 17.

The light source 15a is imaged onto the entrance surface of Light conductor 13a by lens 15b. The radiation flux emitted in the opposite direction is also utilized by means of the concave mirror 15e. The light source is imaged onto the entrance surface of a second light conductor 13b by means of a further lens 15d and a further concave mirror 15e which are mounted so as to be displaced by 90°. The second light conductor 13b is united with the light conductor 13a to conjointly define a common light conductor 13. In this way, not only is a doubled amount of radiation flux of the light source 15a utilized, but the illumination of the surface is relatively independent of the migrations of the focal spot of the light source 15a when the light conductors (13a and 13b) are made up of a plurality of individual fibers which are so well intermingled over the length of the common light conductor 13 that a statistical distribution of the individual fibers is present in the measuring head 11.

The measuring head 11 has a cylindrically-shaped handle 11a through which the light conductors (13, 18a to 18b) and the electrical cables 14 are guided. In addition, the measuring head 11 has a closed handle 11b by means of which it can be hung up on a hook-like suspending device at the work location. The measuring head 11 is easily manipulated and set down on the surface 21 and precisely held during the measurement with the aid of the two handles (11a and 11b).

FIG. 2 is partially in section and shows details of the measuring head 11. Measuring head 11 includes a frame like chassis 22 with a mounting ring 22a on which the illuminating arrangement 23 and the receiving optics (25a, 25b, 25c) are attached. The measuring head is closed off by means of two plate-like formations (not shown) disposed in front of and behind as parallel to the plane of the drawing.

In the illuminating arrangement 23, the end surface of the light conductor 13 is arranged in the focal point of the lens 23a so that the surface 21 is illuminated by a beam having approximately parallel rays. A beam splitter plate 23r is located ahead of lens 23a and a portion of the illuminating radiation is reflected into the comparison beam receiver 24 by the beam splitter plate 23r. The comparison beam receiver 24 includes a path-folding prism (not shown) and a lens (not shown) which concentrates the comparison beam onto the inlet surface (not shown) of the light conductor 18a. The light con-
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ductor 18d leads in the stationary base unit 12 to a diode-
array spectrometer 14d for receiving the comparison
spectrum, that is, the spectrum of the radiation with
which the surfaces 21 is charged.

The radiation regularly reflected from the surface 21
in the direction 23 is received by the light traps (22b
and 22c) in the chassis 22 because this directly reflected
radiation could affect the measurement. The receiving
optics (25a, 25b and 25c) are provided to receive the
reflected radiation and have respective axes (25d, 25e
and 25f) which define the angles of, for example, 25°,
45° and 70° with the direction 23 of the regularly re-
lected radiation.

The receiving optics (25a, 25b and 25c) are all of the
same configuration and include lenses having respective
focal points in the entrance surfaces of corresponding
ones of the light conductors (18a, 18b and 18e). The
receiving optic 25a has a portion of its enclosure broken
away to show this lens 25g. These light conductors lead
to the diode-array spectrometers (16d, 16b and 16c) in
the stationary base unit 12. Diode-array spectrometers
are disclosed, for example, in U.S. Pat. No. 4,598,715.

By considering the comparison spectrum received by
the diode-array spectrometer 16d, absolute values of the
reflection spectra received by the diode-array spec-
 trometers (16b, 16b and 16c) can be detected. The eval-
uation is performed in the conventional manner in the
electronic and evaluation unit 17.

As the light source 12b, a halogen or xenon lamp can,
for example, be used with a pulsed operation of the light
source being advantageous. A short arc discharge lamp
is especially suitable and can, for example, be the lamp
XBO 75 manufactured by Osram or a flash lamp, for
example BGS 2902Z of Heimann, which makes very
short measuring times possible. Both Osram and Hei-
mann are corporations organized and doing business in
the Federal Republic of Germany.

The measuring head 11 has an opening 29 which is
placed on the surface 21 in order to make measure-
ments. A part 28 having mounting surfaces (28a and
28b) made of synthetic material such as polyethylene is
arranged around the opening to prevent the sample
surface from being scratched. In addition, magnets can
be seated in the mounting surface of the measuring head
as an aid to prevent shaking or slipping of the unit dur-
ing measurements of magnetic or magnetizable samples.

Two electrical buttons 26 are provided in the region
of the cylindrically-shaped handle 11a of the measuring
head by means of which the measurement can be initi-
ated and the evaluation unit 17 can be advised whether
the measuring head 11 is seated on a comparison sample
or a sample to be measured. One or several indicating
lamps 27 can provide an indication of the different oper-
ational conditions of the measuring apparatus.

It is understood that the foregoing description is that
of the preferred embodiments of the invention and that
various changes and modifications may be made thereto
without departing from the spirit and scope of the in-
vention as defined in the appended claims.

What is claimed is:

1. A measuring apparatus for characterizing a sur-
face having color directional reflectance properties, the
measuring apparatus comprising:

- a freely movable measuring head having a head hous-
ing;
- a stationary base unit;
- said stationary base unit including a base housing;
- and, a light source mounted in said base housing;

first light conductor means for conducting light from
said light source to said measuring head;

- light directing means mounted in said measuring head
for directing said light onto the surface having said
properties;

a plurality of receiving optics arranged in said head
housing for receiving the light reflected from said
surface;

second light conducting means for conducting the
reflected light to said base unit; and,

said base unit further including a plurality of diode-
array spectrometers for receiving the reflected light
from corresponding ones of said receiving
optics.

2. The measuring apparatus of claim 1, comprising an
electrical cable interconnecting said base unit and said
measuring head, said head housing including a cylindri-

cally-shaped first handle for leading said electrical cable
and said first and second light conductor means into
said head housing, and, a ball-like second handle for
permitting said measuring head to be hung on a hook-
like mounting bracket.

3. The measuring apparatus of claim 1, said light
directing means directing the light onto said surface in
an illuminating beam defining an illuminating beam axis
of which a portion is regularly reflected along a specu-
lar beam axis, said receiving optics defining respective
receiver axes and being mounted in said head housing so
as to cause said receiver axes to define respective angles
with said specular beam axis of 25°, 45° and 70°.

4. The measuring apparatus of claim 3, comprising:
a beam splitter plate mounted in said head housing and
on said illuminating beam axis for splitting out a com-
ponent comparison beam from said illuminating beam;
a comparison beam receiver also mounted in said head
housing for receiving said comparison beam; an addi-
tional diode-array spectrometer mounted in said base
housing; and, third light conducting means for conduct-
ing the light of said comparison beam to said additional
diode-array spectrometer.

5. The measuring apparatus of claim 1, said head
housing having a base for coming into contact engage-
ment with said surface; and, said base being made of a
plastic material.

6. The measuring apparatus of claim 5, said plastic
material being polyethylene.

7. The measuring apparatus of claim 3, said measuring
head including light trapping means mounted in said
head housing for trapping the light regularly reflected
along said specular beam axis.

8. The measuring apparatus of claim 1, said light
source being a halogen lamp.

9. The measuring apparatus of claim 1, said light
source being a xenon lamp.

10. The measuring apparatus of claim 1, said light
source being a flash lamp.

11. The measuring apparatus of claim 1, said light
directing means directing the light onto said surface in
an illuminating beam defining an illuminating beam axis
of which a portion is regularly reflected along a specu-
lar beam axis.

12. The measuring apparatus of claim 11, comprising:
a beam splitter plate mounted in said head housing and
on said illuminating beam axis for splitting out a compo-
nent comparison beam from said illuminating beam; a
comparison beam receiver also mounted in said head
housing for receiving said comparison beam; an addi-
tional diode-array spectrometer mounted in said base
housing; and, third light conducting means for conducting the light of said comparison beam to said additional diode-array spectrometer.

13. The measuring apparatus of claim 11, said measuring head including light trapping means mounted in said head housing for trapping the light regularly reflected along said specular beam axis.